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Lee et al.

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(54) **MOBILE COMMUNICATION DEVICE**

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H04M 1/03 (2006.01)
H04M 1/60 (2006.01)

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CPC ***H04M 1/72569*** (2013.01); *H04M 1/03* (2013.01); *H04M 1/6008* (2013.01); *H04M 1/6016* (2013.01)

(58) **Field of Classification Search**
CPC H04R 19/013; H04M 1/6041
USPC 455/569.1; 381/191
See application file for complete search history.

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Assistant Examiner — Majid Syed
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(57) **ABSTRACT**

A mobile communication device includes: a first sound transceiver including a first lower electrode, a first upper electrode, and a first vibration plate between the first lower electrode and the first upper electrode; a second sound transceiver including a second lower electrode, a second upper electrode, and a second vibration plate between the second lower electrode and the second upper electrode; a position sensor configured to perform a detection of a relative positional relationship between the first and second sound transceivers; and a controller configured to apply a sound signal to one of the first and second sound transceivers and detect a sound signal from the other one thereof, based on the detection result provided from the position sensor.

20 Claims, 6 Drawing Sheets

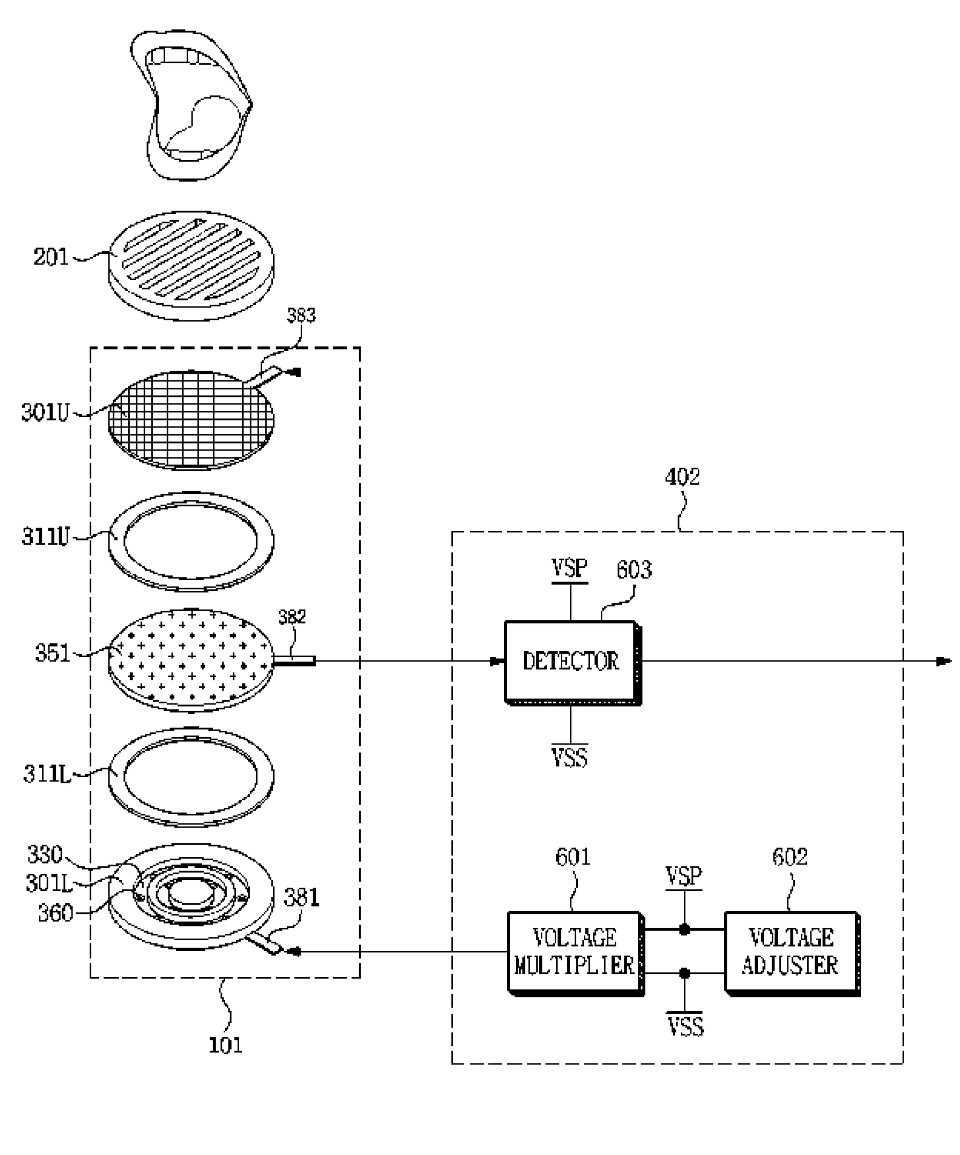

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FIG. 1

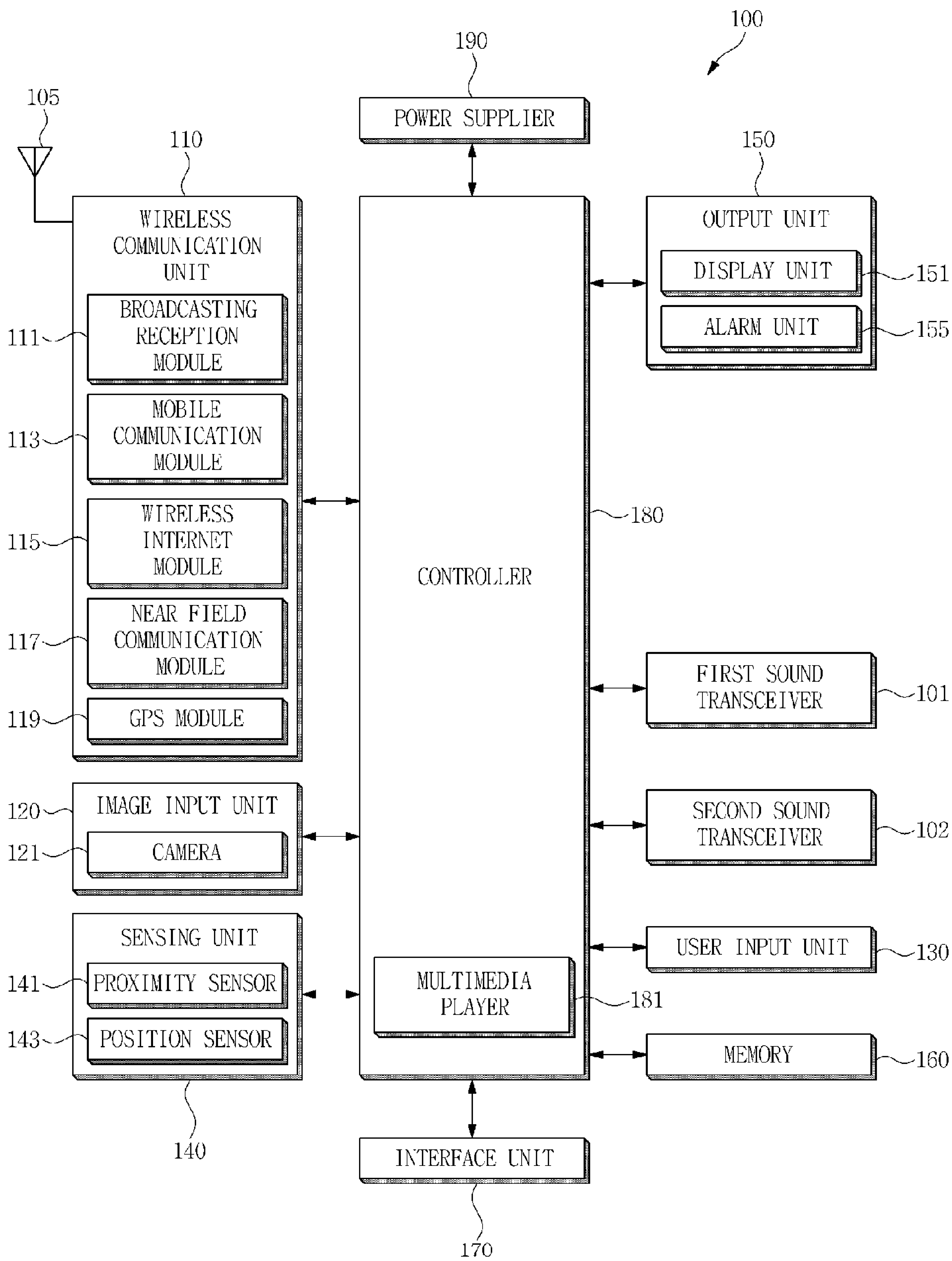

100
190
POWER SUPPLIER
105
110
WIRELESS COMMUNICATION UNIT
111
BROADCASTING RECEPTION MODULE
113
MOBILE COMMUNICATION MODULE
115
WIRELESS INTERNET MODULE
117
NEAR FIELD COMMUNICATION MODULE
119
GPS MODULE
120
IMAGE INPUT UNIT
121
CAMERA
SENSING UNIT
141
PROXIMITY SENSOR
143
POSITION SENSOR
140
CONTROLLER
180
MULTIMEDIA PLAYER
181
INTERFACE UNIT
170
150
OUTPUT UNIT
DISPLAY UNIT
151
ALARM UNIT
155
FIRST SOUND TRANSCEIVER
101
SECOND SOUND TRANSCEIVER
102
USER INPUT UNIT
130
MEMORY
160

FIG. 2

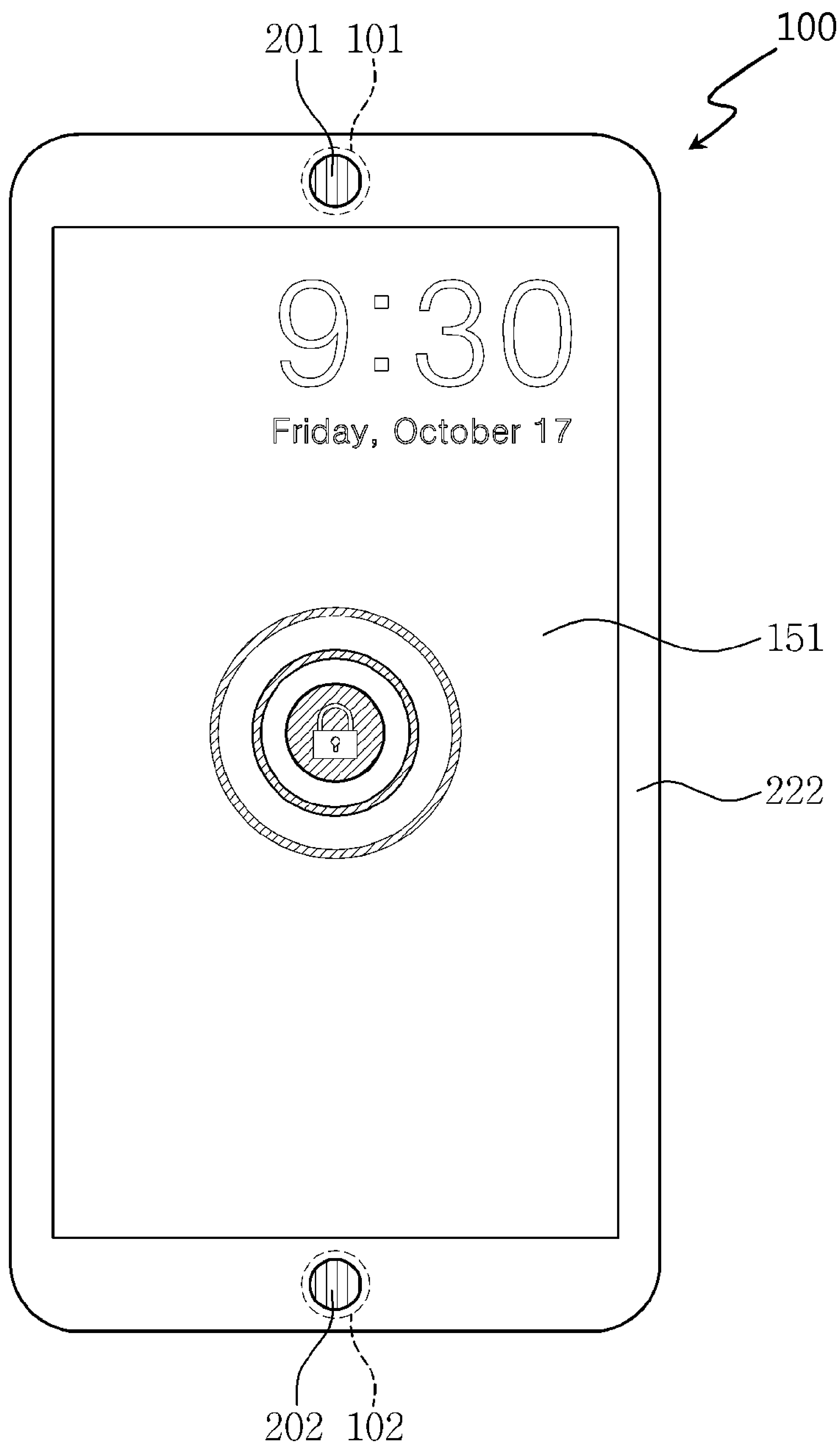


FIG. 3A

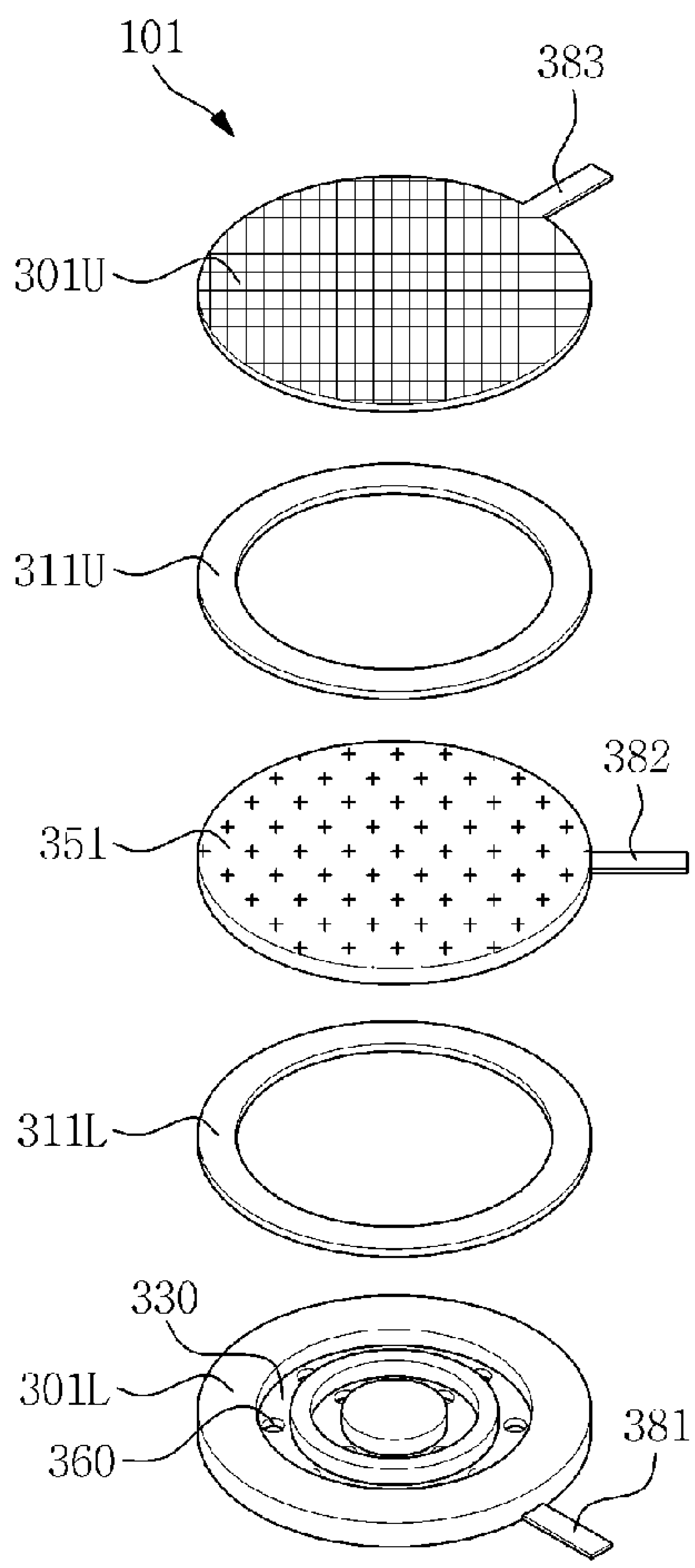

101
383
301U
311U
382
351
311L
330
301L
360
381

FIG. 3B

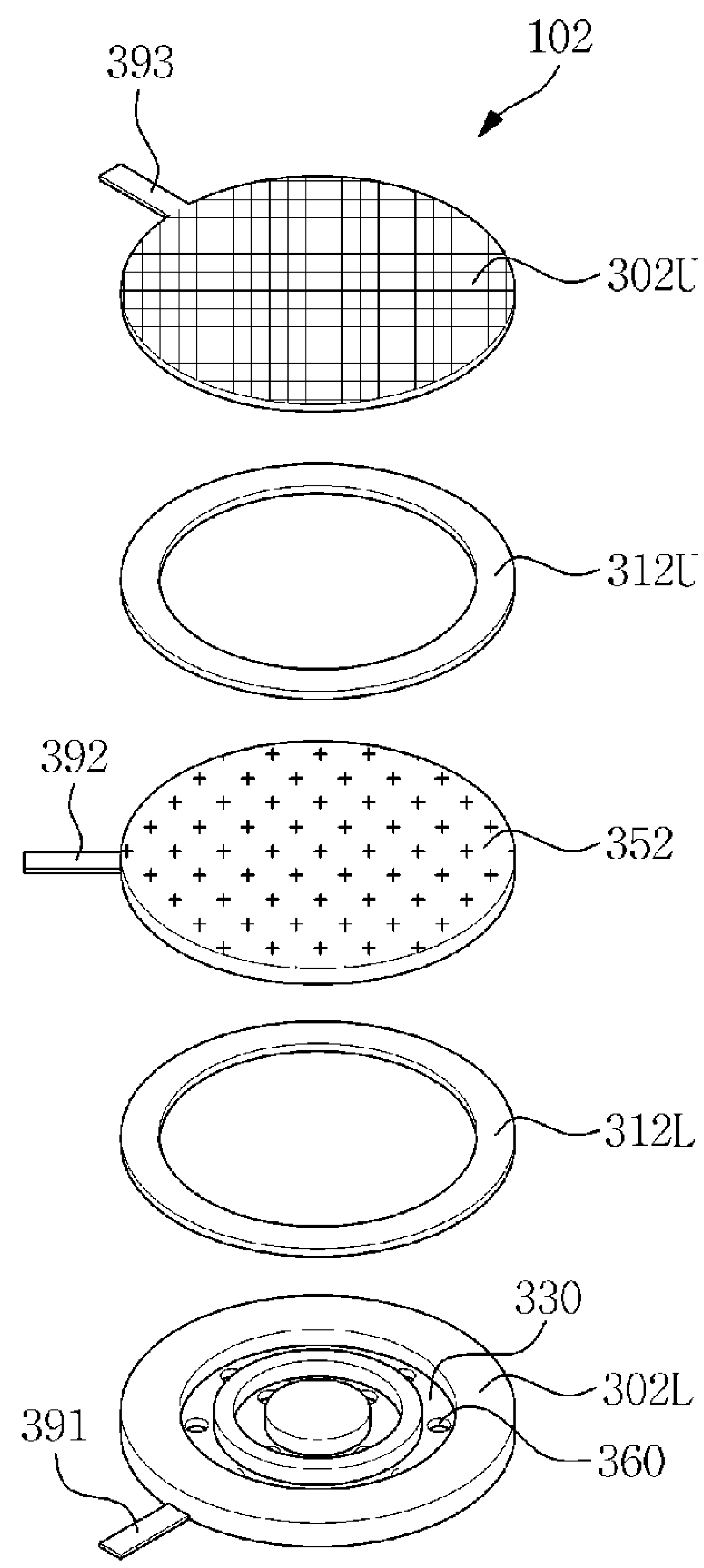

393
102
302U
312U
392
352
312L
330
302L
391
360

FIG. 4

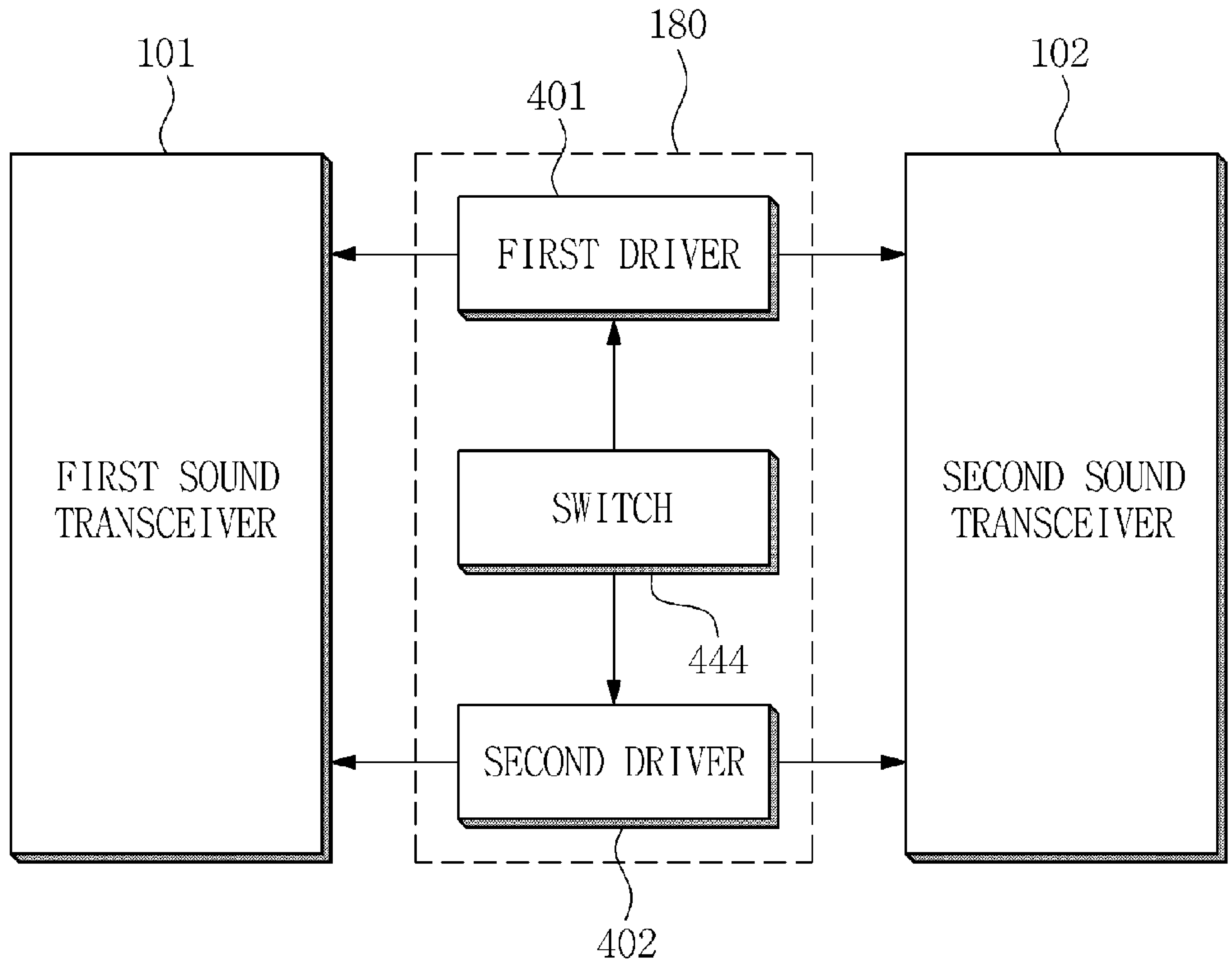
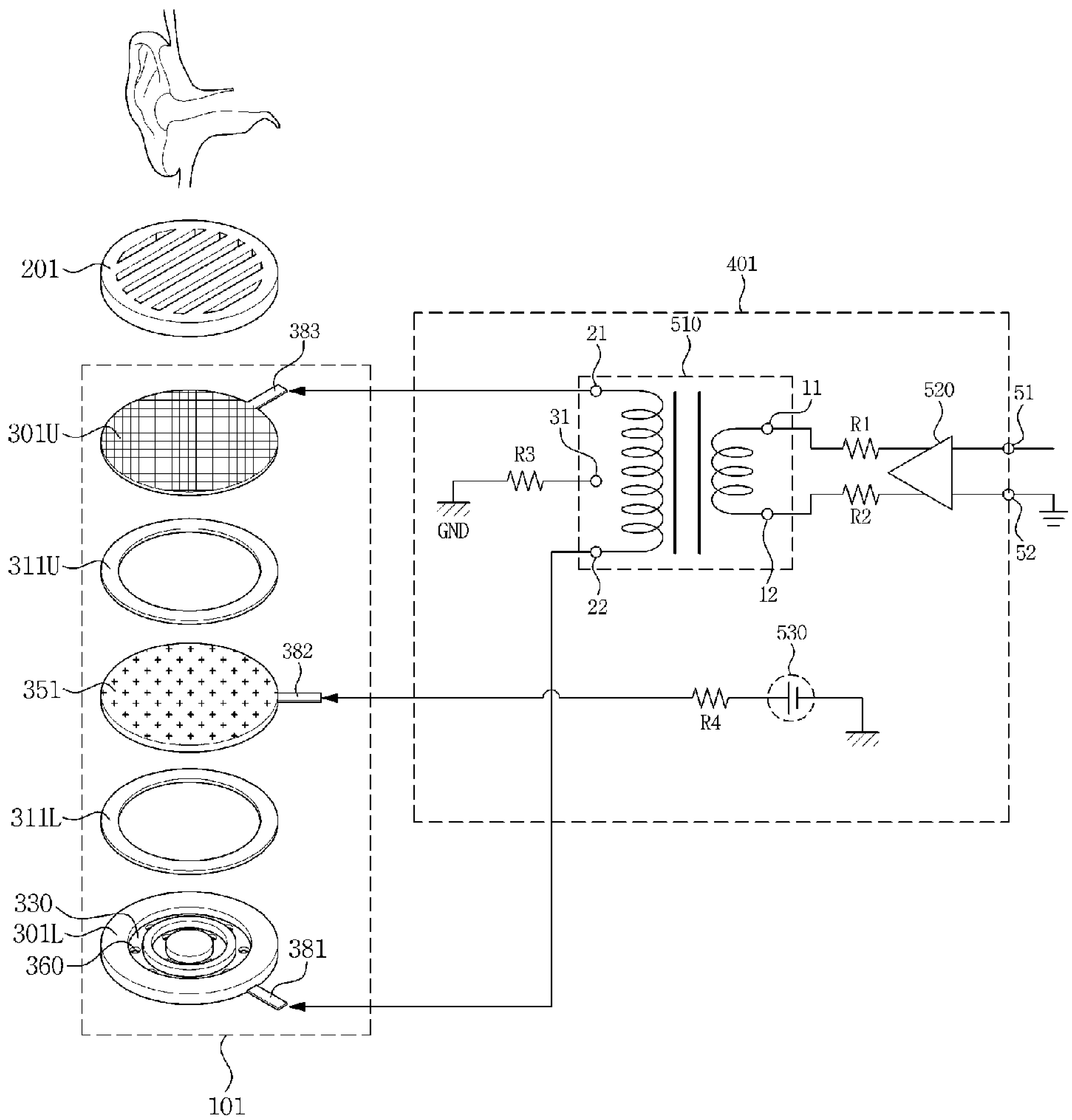
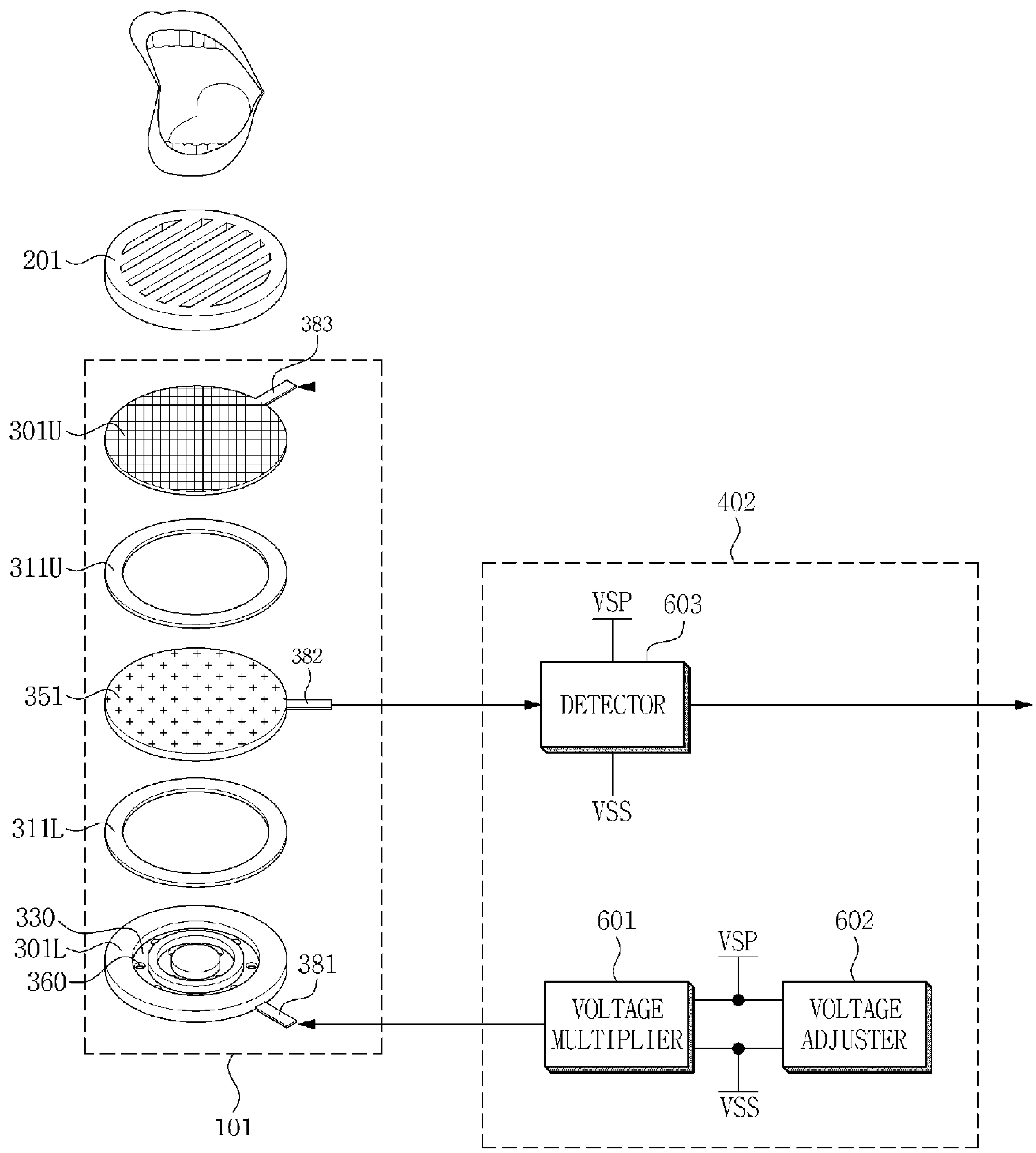

101
180
401
102
FIRST DRIVER
FIRST SOUND TRANSCEIVER
SWITCH
SECOND SOUND TRANSCEIVER
444
SECOND DRIVER
402

FIG. 5



201
383
301U
311U
351
382
311L
330
301L
360
381
101
401
21
510
11
520
51
31
R1
R3
GND
R2
52
22
12
530
R4

FIG. 6


201
383
301U
311U
382
351
311L
330
301L
360
381
101
402
VSP
603
DETECTOR
VSS
601
VSP
602
VOLTAGE MULTIPLIER
VOLTAGE ADJUSTER
VSS

MOBILE COMMUNICATION DEVICE

CLAIM OF PRIORITY

This application claims the priority to and all the benefits of Korean Patent Application No. 10-2014-0161746, filed on Nov. 19, 2014, with the Korean Intellectual Property Office (KIPO), the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

1. Field of Disclosure

Embodiments of the present invention relate to a mobile communication device capable of providing users with a normal phone call environment, even though the user holds the mobile communication device upside down.

2. Description of the Related Art

A mobile communication device refers to a mobile device that provides one or more functions of, for example, a voice and video phone calling function while moving around, an information input and output function, and a data storing function. Such a mobile communication device may include a speaker and a mike so as to support voice phone calls and to play audio sources.

When a speaker and a mike are adjacently disposed, voice played from the speaker may be inputted to the mike, thereby causing howling. Accordingly, a mike and a speaker may be spaced most widely from each other in a case of a mobile communication device, to minimize interference therebetween. In general, a speaker is disposed at an upper portion of a mobile communication device and a mike is disposed at a lower portion thereof.

With the above structure, when a user holds the mobile communication device upside down for the lower portion to be placed upper than the upper portion, a mike may be placed next to an ear of a user and a speaker next to a mouth of the user. In this case, voices of the calling parties may not be properly transmitted, which disrupts phone calls.

Such abnormal phone calls may be easily attributed to quality defects of a telephone call, malfunction of a mobile phone, or a wrong-number phone call. In this case, users may miss important phone calls.

In particular, such cases may frequently happen in a dark environment or when a user with visual impairment may not easily distinguish position of a mike and a speaker of a mobile communication device.

It is to be understood that this background of the technology section is intended to provide useful background for understanding the technology and as such disclosed herein, the technology background section may include ideas, concepts or recognitions that were not part of what was known or appreciated by those skilled in the pertinent art prior to a corresponding effective filing date of subject matter disclosed herein.

SUMMARY OF THE INVENTION

Aspects of embodiments of the present invention are directed to a mobile communication device capable of providing a normal phone call environment although a user holds the mobile communication device upside down.

According to an exemplary embodiment, a mobile communication device includes: a first sound transceiver including a first lower electrode, a first upper electrode, and a first vibration plate between the first lower electrode and the first upper electrode; a second sound transceiver including a

second lower electrode, a second upper electrode, and a second vibration plate between the second lower electrode and the second upper electrode; a position sensor configured to perform a detection of a relative positional relationship between the first and second sound transceivers; and a controller configured to apply a sound signal to one of the first and second sound transceivers and detect a sound signal from the other one thereof, based on the detection result provided from the position sensor.

The controller may apply a sound signal to the first sound transceiver and detect a sound signal from the second sound transceiver, when the first sound transceiver is placed higher than the second sound transceiver.

The controller may apply a sound signal to the first lower electrode and the first upper electrode and apply a first bias voltage to the first vibration plate, and may apply a second bias voltage to the second lower electrode and detect a sound signal from the second vibration plate.

The controller may apply a sound signal to the second sound transceiver and detect a sound signal from the first sound transceiver, when the second sound transceiver is placed higher than the first sound transceiver.

The controller may apply a sound signal to the second lower electrode and the second upper electrode and apply a second bias voltage to the second vibration plate, and may apply a first bias voltage to the first lower electrode and detect a sound signal from the first vibration plate.

The first and second lower electrodes may have a groove and a hole formed within the groove and extending through corresponding lower electrodes.

The mobile communication device may further include a spacer disposed at least one of between the first lower electrode and the first vibration plate, between the first vibration plate and the first upper electrode, between the second lower electrode and the second vibration plate, and between the second vibration plate and the second upper electrode.

The controller may include: a first driver configured to amplify an externally applied sound signal and generate a first bias voltage; a second driver configured to detect a sound signal from one of the first and second sound transceivers and generate a second bias voltage; and a switch configured to apply the amplified sound signal and the first bias voltage applied from the first driver to one of the first and second sound transceivers and to apply the second bias voltage applied from the second driver to the other one thereof, based on the detection result provided from the position sensor.

When the first sound transceiver is placed higher than the second sound transceiver, the first driver may apply a sound signal to the first lower electrode and the first upper electrode and apply a first bias voltage to the first vibration plate; and the second driver may apply a second bias voltage to the second lower electrode and detect a sound signal from the second vibration plate.

When the second sound transceiver is placed higher than the first sound transceiver, the first driver may apply a sound signal to the second lower electrode and the second upper electrode and apply a first bias voltage to the second vibration plate; and the second driver may apply a second bias voltage to the first lower electrode and detect a sound signal from the first vibration plate.

The first driver may include: an amplifier configured to amplify an externally applied sound signal; a transformer configured to transform the amplified sound signal applied from the amplifier; and a bias power configured to generate the first bias voltage.

The second driver may include: a voltage adjuster configured to generate first and second reference voltages based on an externally applied power voltage; a voltage multiplier configured to generate a second bias voltage based on the first and second reference voltages applied from the voltage adjuster; and a detector configured to detect a sound signal from one of the first and second sound transceivers.

The detector may further reduce impedance of the detected sound signal, amplify the modulated sound signal, and convert the amplified sound signal to a digital signal.

The position sensor may be a gravity sensor.

According to embodiments of the present invention, a mobile communication device may have the following effects.

A mobile communication device according to exemplary embodiments may include first and second sound transceivers that may automatically function as one of a speaker and a mike according to its position. Accordingly, the mobile communication device may provide a normal phone call environment although a user holds a mobile communication device upside down.

Further, a lower electrode of the mobile communication device may have a groove and a hole formed thereinside, thereby capable of playing even subtle sound.

The foregoing is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings, in which like reference symbols indicate the same or similar components, wherein:

FIG. **1** is a block diagram illustrating a mobile communication device according to an exemplary embodiment;

FIG. **2** is a view illustrating exterior appearance of the mobile communication device according to an exemplary embodiment;

FIGS. **3**A and **3**B are exploded perspective views illustrating first and second sound transceivers, respectively, of FIG. **2**;

FIG. **4** is a block diagram illustrating a controller of FIG. **1**;

FIG. **5** is a detailed configuration view illustrating a first driver of FIG. **4**; and

FIG. **6** is a detailed configuration view illustrating a second driver of FIG. **4**.

DETAILED DESCRIPTION

Advantages and features of the present invention and methods for achieving them will be made clear from embodiments described below in detail with reference to the accompanying drawings. The present invention may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The present invention is merely defined by the scope of the claims. Therefore, well-known constituent elements, operations and techniques are not described in detail in the embodiments in order to prevent the present invention from being obscurely interpreted. Like reference numerals refer to like elements throughout the specification.

In the drawings, thicknesses are illustrated in an enlarged manner in order to clearly describe a plurality of layers and areas. Like reference numbers are used to denote like elements throughout the specification. When an element or layer is referred to as being "on", "engaged to", "connected to" or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to", "directly connected to" or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

The spatially relative terms "below", "beneath", "lower", "above", "upper", and the like, may be used herein for ease of description to describe the relations between one element or component and another element or component as illustrated in the drawings. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation, in addition to the orientation depicted in the drawings. For example, in the case where a device shown in the drawing is turned over, the device positioned "below" or "beneath" another device may be placed "above" another device. Accordingly, the illustrative term "below" may include both the lower and upper positions. The device may also be oriented in the other direction, and thus the spatially relative terms may be interpreted differently depending on the orientations.

Throughout the specification, when an element is referred to as being "connected" to another element, the element is "directly connected" to the other element, or "electrically connected" to the other element with one or more intervening elements interposed therebetween. It will be further understood that the terms "comprises," "comprising," "includes" and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

It will be understood that, although the terms "first," "second," "third," and the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. Thus, "a first element" discussed below could be termed "a second element" or "a third element," and "a second element" and "a third element" can be termed likewise without departing from the teachings herein.

Unless otherwise defined, all terms used herein (including technical and scientific terms) have the same meaning as commonly understood by those skilled in the art to which this invention pertains. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an ideal or excessively formal sense unless clearly defined in the present specification.

Herein, a mobile communication device may include a mobile phone, a smart phone, a notebook computer, a digital broadcasting terminal, a personal digital assistant (PDA), a portable multimedia player (PMP), and navigation. Further, suffixes "module" and "part" for components used herein are simply given for ease of description and may not impart particular significance or role by itself. Thus, the terms "module" and "part" may be interchangeable.

Herein, "sound" is to be understood as having concept including both sound produced by an object and voice of a human being.

FIG. **1** is a block diagram illustrating a mobile communication device **100** according to an exemplary embodiment. Functional configurations of the mobile communication device **100** according to an exemplary embodiment will be described with reference to FIG. **1**.

Referring to FIG. **1**, the mobile communication device **100** may include a wireless communication unit **110**, an image input unit **120**, a user input unit **130**, a sensing unit **140**, an output unit **150**, a memory **160**, an interface unit **170**, a controller **180**, and a power supplier **190**. Each of the configurations may be subdivided into two or more components or two or more configurations may be combined into a single component, where necessary in actual applications.

The wireless communication unit **110** may include a broadcasting reception module **111**, a mobile communication module **113**, a wireless internet module **115**, a near field communication module **117**, and a global position system (GPS) module **119**. Herein, the wireless communication unit **110** may externally receive information using an antenna **105**.

The broadcasting reception module **111** may receive at least one of broadcasting signals and broadcasting information from an external broadcast management server over broadcast channels. In this case, the broadcast channel may include, for example, a satellite channel and a terrestrial channel. The broadcast server may refer to a server that generates and transmits at least one of broadcasting signals and broadcasting information or a server that receives at least one of the generated broadcasting signals and broadcasting information to thereby transmit to a terminal.

The broadcasting information may refer to information pertaining to broadcasting channels, broadcasting programs, or broadcasting service providers. The broadcasting signal may include TV broadcasting signals, radio broadcasting signals, data broadcasting signals, and may also include broadcasting signals of data broadcasting signals combined with the TV broadcasting signals or radio broadcasting signals. The broadcasting information may be provided over a wireless communication network and may be, in this case, received by the mobile communication module **113**. The broadcasting information may be present in many different forms. The broadcasting information may be provided in the form of, for example, electronic program guide (EPG) of digital multimedia broadcasting (DMB) or electronic service guide (ESG) of digital video broadcast-handheld (DVB-H).

The broadcasting receiving module **111** may receive broadcasting signals, employing various broadcasting systems, such as, in particular, digital broadcasting systems including digital multimedia broadcasting-terrestrial (DMB-T), digital multimedia broadcasting-satellite (DMB-S), media forward link only (MediaFLO), digital video broadcast-handheld (DVB-H), and integrated services digital broadcast-terrestrial (ISDB-T). Further, the broadcasting receiving module **111** may be composed to be applicable to all broadcasting systems that provide broadcasting signals, as well as the digital broadcasting system. The broadcasting signals and/or broadcasting information provided by the broadcasting receiving module **111** may be stored in the memory **160**.

The mobile communication module **113** may perform transmission and/or reception with at least one of a base station, an external terminal, and a server over a wireless communication network. Herein, the wireless signal may include various types of data according to transmission and/or reception of voice call signals, video phone call signals, short message service (SMS), or multimedia message.

The wireless internet module **115** refers to a module for wireless internet connection. The wireless internet module **115** may be equipped within the mobile communication device **100** or may be equipped exteriorly. Wireless LAN (WLAN), Wi-Fi, wireless broadband (Wibro), world interoperability for microwave access (Wimax), and high speed downlink packet access (HSDPA) may be employed as wireless internet technology.

The near field communication module **117** may perform near field communication with another mobile communication device using, for example, bluetooth, radio frequency identification (RFID), infrared data association (IrDA), ultra wideband (UWB), and zigbee (ZigBee).

The GPS module **119** may receive location information from a plurality of GPS satellites. The GPS module **119** may receive location information of the mobile communication device **100** and provide the received location information to the controller **180**.

The image input **120** is configured to externally receive image signals and may include, for example, a camera **121**. The camera **121** may process image frames such as still images or moving images obtained by an image sensor, in a video phone call mode or a photography mode. The processed image frame may be displayed on a display unit **151**.

The image frames processed by the camera **121** may be stored in the memory **160** or transmitted outwards through the wireless communication unit **110**. Two or more of the cameras **121** may be provided according to the configuration of the mobile communication device **100**.

The user input **130** is configured to input various instructions of users for controlling operation of the mobile communication device **100**. The user input **130** may include a key pad, a dome switch, a touchpad (static pressure/electrostatic), a jog wheel, a jog switch, a finger mouse, and the like. In particular, a touch screen refers to a structure where a touchpad forms an inter-systematic structure with the display unit **151** described below.

The sensing unit **140** may detect the current state of the mobile communication device **100**, such as open and close state, position, and presence of user contact of the mobile communication device **100** to thereby generate sensing signals to control operation of the mobile communication device **100**. For instance, when the mobile communication device **100** is provided in a slide phone type, the sensing unit **140** may detect the open and close state of the slide phone. Further, the sensing unit **140** may detect presence of power supply from the power supplier **190** and whether or not the interface unit **170** is connected to an external device.

The sensing unit **140** may include a proximity sensor **141** and a position sensor **143**.

The proximity sensor **141** may detect an approaching object or the presence of an adjacent object without mechanical connection. The proximity sensor **141** may utilize variation of alternating magnetic field, variation of static magnetic field, or a variation ratio of capacitance so as to detect an adjacent object. Two or more proximity sensors

141 may be provided according to configuration of the mobile communication device **100**.

The position sensor may detect a relative positional relationship between the first and second sound transceivers. For instance, the position sensor may be a gravity sensor that determines a relative positional relationship between the first and second sound transceivers **101** and **102** with respect to a gravity direction.

The output unit **150** is configured to output image signals or alarm signals. The output unit **150** may include, for example, the display unit **151** and an alarm unit **155**.

The display unit **151** may display information processed from the mobile communication device **100**. For instance, the display unit **151** may display, when the mobile communication device **100** is in a phone call mode, user interface (UI) or graphic user interface (GUI) that are associated with phone calls. Further, the display unit **151** may display, when the mobile communication device **100** is in a video phone call mode or a photography mode, filmed images and provided images respectively or simultaneously. In this case, the display unit **151** may further display UI or GUI.

Meanwhile, as set forth above, when the display unit **151** and the touchpad inter-systematically constitute a touch screen, the display unit **151** may be utilized as an input device. The display unit **151** may include, when utilized as a touch screen, a touch screen panel and a touch screen panel controller. In this case, the touch screen panel may be a transparent panel attached outside and may be connected to an internal bus of the mobile communication device **100**. The touch screen panel may monitor presence of touch and may apply, when a touch input occurs, corresponding signals to the touch screen panel controller. The touch screen panel controller may process the signals and transmit data corresponding to the signals to the controller **180**. The controller **180** may recognize the presence of a touch input and which area of the touch screen is touched.

The display unit **151** may include at least one of an LCD, an OLED display, a flexible display, and a 3D display. Further, two or more display units **151** may be provided according to the type of the mobile communication device **100**. In some embodiments, both an external display unit (not illustrated) and an internal display unit (not illustrated) may be provided together in the mobile communication device **100**.

The first and second sound transceivers **101** and **102** may function as one of a speaker and a mike according to the relative positional relationship therebetween. For instance, when the first sound transceiver **101** is placed higher than the second sound transceiver **102**, with respect to the gravity direction, the first sound transceiver **101** may function as a speaker while the second sound transceiver **102** may function as a mike. In contrast, when the second sound transceiver **102** is placed higher than the first sound transceiver **101**, with respect to the gravity direction, the second sound transceiver **102** may function as a speaker while the first sound transceiver **101** may function as a mike.

When the first sound transceiver **101** functions as a speaker, the first sound transceiver **101** may output sound signals provided from the wireless communication unit **110** or sound signals stored in the memory **160**, in a call signal reception mode, a voice call mode, a video phone call mode, a record mode, a voice recognition mode, or a broadcasting reception mode. Further, the first sound transceiver **101** that functions as a speaker may output sound signals associated with functions performed in the mobile communication device **100**, such as an incoming call sound and an incoming message sound.

Meanwhile, when the first sound transceiver **101** functions as a mike, the first sound transceiver **101** may externally receive sound and convert the sound into electric sound signals, in the voice call mode, the video phone call mode, the record mode, and the voice recognition mode. The converted sound signal, when the mobile communication device **100** is in the voice call mode or the video phone call mode, may be converted into a form that can be transmitted to a wireless communication base station through the mobile communication module **113**. The first sound transceiver **102** functioning as a mike may employ various noise removal algorithm so as to remove noise occurring when externally receiving sound.

The second sound transceiver **102** may operate identically to the first sound transceiver **101**. That is, operation of the second sound transceiver **102** as a speaker is identical to the operation of the first sound transceiver **101** as a speaker, and operation of the second sound transceiver **102** as a mike is identical to the operation of the first sound transceiver **101** as a mike.

The alarm unit **155** may output signals to notify occurrence of events of the mobile communication device **100**. Examples of the event occurring at the mobile communication device **100** may include, for example, an incoming call, an incoming message, and an input key signal. The alarm unit **155** may output other types of signals, rather than sound signals or video signals, to notify occurrence of events. In some embodiments, the alarm unit **155** may output vibration signals. When there is an incoming call or an incoming message, the alarm unit **155** may output signals to notify the reception. Further, when a key signal is input, the alarm unit **155** may output a signal as a feedback in response to the input key signal.

Users may recognize the occurrence of events with the signals outputted from the alarm unit **155**. The signals notifying occurrence of events may be outputted through the display unit **151** and one of the first and second sound transceivers **101** and **102** in the mobile communication device **100**.

The memory **160** may be stored with programs to process and control the controller **180** and may function to temporally store input or output data (e.g., a phone book, a message, a static image, and a video).

The memory **160** may include at least one type of storage mediums of a flash memory, a hard disk, a multimedia microcard, a card type memory (e.g., a secure digital (SD) memory or an XD memory), RAM, and ROM.

The interface unit **170** may function as an interface with all external devices connected to the mobile communication device **100**. Examples of the external devices connected to the mobile communication device **100** may include a wire/wireless headset, an external charger, a wire/wireless data port, a memory card, a card socket for SIM/UIM cards, an audio input/output (I/O) terminal, a video TO, and an earphone. The interface unit **170** may receive data or power from the external device and transmit the data or power to each element within the mobile communication device **100** and may also transmit the inside data of the mobile communication device **100** to the external device.

The controller **180** may control each of the above-described elements to control overall operation of the mobile communication device **100**. For instance, the controller **180** may control and perform processes of a voice call, data communication, a video phone call, and the like.

Further, the controller **180** may include a multimedia player **181** for playing multimedia. The multimedia player **181** may be provided as hardware within the controller **180**.

In some embodiments, the multimedia player **181** may be formed separately from the controller **180**, and may be, in this case, formed as software.

Further, based on the detection result provided from the position sensor **143**, the controller **180** may provide sound signals to one of the first and second sound transceivers **101** and **102** and detect sound signals from the other one thereof. In other words, when relative positional relationship between the first and second sound transceivers **101** and **102** is determined by the position sensor **143**, the controller **180** may determine which one of the two sound transceivers **101** and **102** to operate as a speaker. When a sound transceiver to be operated as a speaker is selected, the other sound transceiver, which is not selected, may be automatically controlled to function as a mike. The operation of the controller **180** is described below in detail with examples.

For instance, when a user holds a mobile communication device **100** upright, the first sound transceiver **101** is placed higher than the second sound transceiver **102**. In this case, the first sound transceiver **101** is placed next to the user's ear and the second sound transceiver **102** is placed next to the user's mouth. In this case, a position sensor **143** may detect the position and provide information on the relative positional relationship between the sound transceivers **101** and **102** to a controller **180**. Next, the controller **180** may apply sound signals to the first sound transceiver **101** and detect sound signals from the second sound transceiver **102**. Accordingly, the first sound transceiver **101** may function as a speaker and the second sound transceiver **102** may function as a mike. Then, sound may be output outwardly of the mobile communication device **100** through the first sound transceiver **101** functioning as a speaker and sound may be input inwardly of the mobile communication device **100** through the second sound transceiver **102** functioning as a mike. In detail, in the case of the voice call mode, the first sound transceiver **101** functioning as a speaker may transmit voice signals of another user on the phone provided from the wireless communication unit **110** to the user of the mobile communication device **100**. Further, in the voice call mode, the second sound transceiver **102** functioning as a mike may receive voice of the user of the mobile communication device **100** and convert the voice into electric sound signals. The converted sound signals may be transmitted to a mobile communication device **100** of the another user on the phone via the mobile communication module **113**.

In contrast, when a user holds a mobile communication device **100** upside down (i.e., a lower portion is placed higher than an upper portion), the second sound transceiver **102** is placed higher than the first sound transceiver **101**. In this case, the second sound transceiver **102** is placed next to the user's ear and the first sound transceiver **101** is placed next to the user's mouth. Then, the position sensor may detect the position and provide information on the relative positional relationship between the two sound transceivers **101** and **102** to a controller **180**. Next, the controller **180** may apply sound signals to the second sound transceiver **102** and detect sound signals from the first sound transceiver **101**. Accordingly, the second sound transceiver **102** may function as a speaker and the first sound transceiver **101** may function as a mike. Then, sound may be output outwardly of the mobile communication device **100** through the second sound transceiver **102** and sound may be input inwardly of the mobile communication device **100** through the first sound transceiver **101**. For instance, the second sound transceiver **102** functioning as a speaker may transmit voice signals of another user on the phone provided from the wireless communication unit **110** to the user of the mobile communication device **100**. Further, the first sound transceiver **101** functioning as a mike may receive voice of the user of the mobile communication device **100** and convert the voice into electric sound signals. The converted sound signals may be transmitted to a mobile communication device **100** of the another user on the phone via the mobile communication module **113**.

Accordingly, the mobile communication device **100** according to embodiments of the present invention may provide users with a normal phone call environment although a user holds a mobile communication device **100** upside down.

The power supplier **190** may receive external and inner power and provide each element with the power required for the operation, which is controlled by the controller **180**.

The mobile communication device **100** with the above configuration may include a wire/wireless communication system and a satellite-based communication system to be operable in a communication system where data may be transmitted through frames and packets.

Hereinafter, the mobile communication device **100** according to an exemplary embodiment will be described with respect to exterior appearance. Hereinafter, a bar-type mobile communication device is described as an example, for ease of description, among mobile communication device types of a folder type, a bar type, a swing type, and a slider type. However, the present invention is not limited to the bar type mobile communication device, and thus applicable to all types of mobile communication devices including the bar type.

FIG. **2** is a view illustrating exterior appearance of the mobile communication device **100** according to an exemplary embodiment.

The mobile communication device **100** may include, as illustrated in FIG. **2**, a display unit **151** and a case **222** that surrounds the display unit.

The display unit **151** may include, for example, an LCD or an OLED that visually displays information. The display unit **151** may include touchpads overlapped with each other in a layer structure, such that the display unit **151** may operate as a touch screen to allow a user to input information by touch. A first sound transceiver **101** may be realized into a receiver or a speaker form. The first camera **121***a* may be realized to allow users to photograph images or to film videos.

The case **222** may cover an edge portion and a rear surface of the display unit **151**. The first and second sound transceivers **101** and **102** may be disposed within the case **222**. The first sound transceiver **101** may be disposed at one end portion of the mobile communication device **100** and the second sound transceiver **102** may be disposed at another end portion of the mobile communication device **100**. Herein, the one end portion and the another end portion may be an upper portion and a lower portion of the mobile communication device **100**, respectively.

The case **222** may further include first speaker grill **201** and second speaker grill (not shown) and first and second holes (not shown) into which the first and second speaker grills are respectively inserted. The first and second speaker grills may be a cylinder in shape. The first speaker grill may have a plurality of holes extending therethrough and the second speaker grill may have a plurality of holes extending therethrough. The first speaker grill **201** may be disposed on the first sound transceiver **101** and the second speaker grill (not shown) may be disposed on the second sound transceiver **102**.

The case **222** may be formed by injecting synthetic resins and may include metal materials, such as stainless steel (STS) or titanium (Ti).

FIGS. **3**A and **3**B are exploded perspective views illustrating first and second sound transceivers **101** and **102**, respectively, of FIG. **2**.

The first sound transceiver **101** may include, as illustrated in FIG. **3**A, the first lower electrode **301**L, a first lower spacer **311**L, a first vibration plate **351** (e.g. diaphragm), a first upper spacer **311**U and the first upper electrode **301**U.

The first lower electrode **301**L may be disposed on a base surface within the case **222**. The first lower electrode **301**L may include a film and a conductive layer disposed on one surface of the film. Herein, the one surface of the film refers to a surface facing the first lower spacer **311**L. The film may be a synthetic resin film having insulating and flexible properties, such as polyethylene terephthalate (PE) or polypropylene (PP). The conductive layer may be metal having conductive properties. The conductive layer may be attached on one surface of the film in a deposition method. Further, at least one groove **330** may be formed on one surface of the first lower electrode **301**L. The groove **330** may be circular in shape, surrounding a center portion of the first lower electrode **301**L. Further, within each groove **330**, at least one hole **360** extending through the first lower electrode **301**L may be formed. Air and sound may pass through the first lower electrode **301**L through the holes **360**. The first lower electrode **301**L may be circular in shape. Meanwhile, the first lower electrode **301**L may include an electrode **381** to receive sound signals or a second bias voltage.

The first lower spacer **311**L may be disposed on the first lower electrode **301**L. The first lower spacer **311**L may pass air and sound therethrough. The first lower spacer **311**L may not, however, pass electricity therethrough. The first lower spacer **311**L may have elasticity, and thus may be deformed under external force and then return to its original shape when the external force is removed. The first lower spacer **311**L may include materials such as felt. The first lower spacer **311**L may be provided in a loop shape with an empty center portion.

The first vibration plate **351** may be disposed on the first lower spacer **311**L. The first vibration plate **351** may include a film and a conductive layer disposed on one surface of the film. Herein, the one surface of the film refers to a surface facing the first lower spacer **311**L. The film may be a synthetic resin film having insulating and flexible properties, such as PE or PP. The conductive layer may be metal having conductive properties. For instance, one of graphene, platinum (Pt), gold (Au), diamond-like carbon (DLC) may be utilized as materials of the conductive layer. The conductive layer may be attached on one surface of the film in a deposition method. The first vibration plate **351** may be circular in shape. Meanwhile, the first vibration plate **351** may include an input terminal **382** to receive a first bias voltage. The input terminal may be a part of the conductive layer. The first vibration plate **351** may be called as a diaphragm.

The first upper spacer **311**U may be disposed on the first vibration plate **351**. The first upper spacer **311**U may have identical configurations and materials as in the first lower spacer **311**L. Meanwhile, at least a part of an edge portion of the first upper spacer **311**U may be bonded to at least a part of an edge portion of the first lower spacer **311**L using an adhesive member.

The first upper electrode **301**U may be disposed on the first upper spacer **311**U. The first upper electrode **301**L may include a film and a conductive layer disposed on one surface of the film. The film may be a synthetic resin film having insulating and flexible properties, such as PE or PP, as described above. The conductive layer may be metal having conductive properties. The conductive layer may be attached on one surface of the film in a deposition method. Further, the first upper electrode **301**U may have a plurality of holes extending therethrough, such that air and sound may pass through the first upper electrode **301**U. The holes may be arranged in a mesh shape. Meanwhile, the first upper electrode **301**U may include an input terminal **383** to receive sound signals. The input terminal **383** may be a part of the conductive layer. A sound signal applied to the first upper electrode **301**U and a sound signal applied to the second lower electrode **301**L may respectively have voltages opposite in polarity.

The second sound transceiver **102** may include, as illustrated in FIG. **3**B, the second lower electrode **302**L, a second lower spacer **312**L, a second vibration plate **352**, a second upper spacer **312**U, and the second upper electrode **302**U. The second lower electrode **302**L may include an electrode **391** to receive sound signals or a second bias voltage, and the second vibration plate **352** may include an input terminal **392** to receive a first bias voltage, and the second upper electrode **302**U may include an input terminal **393** to receive sound signals.

The second lower electrode **302**L, the second lower spacer **312**L, the second vibration plate **352**, the second upper spacer **312**U, and the second upper electrode **302**U may be identical to the first lower electrode **302**L, the first lower spacer **312**L, the first vibration plate **352**, the first upper spacer **312**U, and the first upper electrode **302**U, and thus repeated description will not be provided.

As described above, the first and second sound transceivers **101** and **102** may be substantially identical in configuration. The first and second sound transceivers **101** and **102** may, however, function as a speaker or a mike according to a signal applied thereto. For instance, when a sound signal is applied to the first lower electrode **301**L and the first upper electrode **301**U and a first bias voltage is applied to the first vibration plate **351**, the first sound transceiver **101** may function as a speaker. In contrast, when a second bias voltage is applied to the first lower electrode **301**L and the first upper electrode **301**U is subject to floating, the first sound transceiver **101** may function as a mike. In this case, sound signal may be detected by the first vibration plate **351**. Likewise, when a sound signal is applied to the second lower electrode **302**L and the second upper electrode **302**U and a first bias voltage is applied to the second vibration plate **352**, the second sound transceiver **102** may function as a speaker. In contrast, when the second bias voltage is applied to the second lower electrode **302**L and the second upper electrode **302**U is subject to floating, the second sound transceiver **102** may function as a mike.

In order to selectively supply the sound signal, the first and second bias voltages to the first and second sound transceiver **101** and **102**, the controller **180** may have the following configuration.

FIG. **4** is a block diagram illustrating a controller of FIG. **1**.

The controller **180** may include, as illustrated in FIG. **4**, a first driver **401**, a second driver, and a switch.

The first driver **401** may amplify externally applied sound signals and generate a first bias voltage. Herein, the externally applied sound signal may be an alternating current (AC) voltage and may be, for example, voice signals of another user applied from the wireless communication unit **110**.

The second driver **402** may detect sound signals from one of the first and second sound transceivers **101** and **102** and generate a second bias voltage. Herein, the sound signal may be an analog signal and may be, for example, a signal generated based on voice of the user of the mobile communication device **100**.

The switch **444** may determine a sound transceiver **101** or **102** to be connected to the first driver **401** and determine a sound transceiver **101** or **102** to be connected to the second driver **402**, based on the detection result provided from the position sensor **143**. In other words, the switch **444** may provide the amplified sound signal applied from the first driver **401** and the first bias voltage to one of the first and second sound transceivers **101** and **102**, based on the detection result provided from the position sensor **143**. Then, the switch **444** may provide the second bias voltage applied from the second driver **402** to the other sound transceiver. The operation is described in detail with the following examples.

In a case where the first sound transceiver **101** is placed higher than the second sound transceiver **102**, the controller **180** may electrically connect the first driver **401** and the first sound transceiver **101** and electrically connect the second driver **402** and the second sound transceiver **102**. Accordingly, sound signals may be applied to the first lower electrode **301**L and the first upper electrode **301**U of the first sound transceiver **101** and a first bias voltage may be applied to the first vibration plate **351**. Then, when a second bias voltage is applied to the second lower electrode **302**L of the second sound transceiver **102** and the second upper electrode **302**U is subject to floating, a detection terminal of the second driver **402** is connected to an electrode of the second vibration plate **352**.

In another case where the second sound transceiver **102** is placed higher than the first sound transceiver **101**, the controller **180** may electrically connect the first driver **401** and the second sound transceiver **102** and electrically connect the second driver **402** and the first sound transceiver **101**. Accordingly, sound signals may be applied to the second lower electrode **302**L and the second upper electrode **302**U of the second sound transceiver **102** and a first bias voltage may be applied to the second vibration plate **352**. Then, when a second bias voltage is applied to the first lower electrode **301**L of the first sound transceiver **101** and the first upper electrode **301**U is subject to floating, a detection terminal of the second driver **402** is connected to an electrode of the first vibration plate **352**.

FIG. **5** is a detailed configuration view illustrating the first driver **401** of FIG. **4**. In particular, FIG. **5** illustrates connection relationship between the first sound transceiver **101** and the first driver **401** when the first sound transceiver **101** functions as a speaker.

The first driver **401** may include, as illustrated in FIG. **5**, a transformer **510**, an amplifier **520**, and a bias power **530**.

The amplifier **520** may amplify sound signals input to a first input terminal **51** and output the amplified sound signal. Further, a second input terminal **52** of the amplifier **520** may be grounded.

The transformer **510** may transform the sound signal amplified by the amplifier **520** and output the transformed sound signal. A first input terminal **11** of the transformer **510** may be connected to the amplifier **520** through a first resistor R1. A second input terminal **12** of the transformer **510** may be connected to the amplifier **520** through a second resistor R2. A first output terminal **21** of the transformer **510** may be connected to the first upper electrode **301**U. In this case, the first output terminal **21** may be connected to the conductive layer of the first upper electrode **301**U through the input terminal **383**. A second output terminal **22** of the transformer **510** may be connected to the first lower electrode **301**L. In this case, the second output terminal **22** may be connected to the conductive layer of the first lower electrode **301**L through the input terminal **381**. A center-point terminal **31** of the transformer **510** may be connected to ground, which is a reference potential of the first driver **401**, through a third resistor R3.

The bias power may generate a first bias voltage, which is a DC voltage. One terminal of the bias power may be connected to the first vibration plate **351** through a fourth resistor R4 and another terminal thereof may be connected to ground, which is a reference potential of the first driver **401**. The bias power may apply the first bias voltage to the first vibration plate **351**.

With the above described configuration, operation of the first driver **401** and the first sound transceiver **101** are described below in detail.

When a sound signal is inputted to the amplifier **520** and amplified, voltage corresponding to the amplified sound signal is applied to the first upper electrode **301**U and the first lower electrode **301**L through the transformer **510**. Then, when a potential difference occurs between the first upper electrode **301**U and the first lower electrode **301**L by the applied voltage, electrostatic force may be applied to the first vibration plate **351** between the first upper electrode **301**U and the first lower electrode **301**L. The electrostatic force may exert its influence in a direction to draw the first vibration plate **351** toward one of the first upper electrode **301**U and the first lower electrode **301**L. Due to the electrostatic force, the first vibration plate **351** may be more adjacently disposed to one of the first upper electrode **301**U and the first lower electrode **301**L.

For instance, it is assumed that a positive voltage is applied to the first upper electrode **301**U by the sound signal applied to the first driver **401** and a negative voltage is applied to the first lower electrode **301**L. In this case, since the first vibration plate **351** is applied with a positive voltage due to the bias power, electrostatic force between the first vibration plate **351** and the first upper electrode **301**L, to which voltages of an identical polarity are respectively applied, may become relatively weak, whereas electrostatic force between the first vibration plate **351** and the first lower electrode **301**L, to which voltages of the opposite polarities are respectively applied, may become relatively strong. Accordingly, the first vibration plate **351** may be drawn toward the first lower electrode **301**L.

In contrast, it is assumed that a negative voltage is applied to the first upper electrode **301**U by the sound signal applied to the first driver **401** and a positive voltage is applied to the first lower electrode **301**L. In this case, since the first vibration plate **351** is applied with a positive voltage due to the bias power, electrostatic force between the first vibration plate **351** and the first lower electrode **301**L, to which voltages of the identical polarity are respectively applied, may become relatively weak, whereas electrostatic force between the first vibration plate **351** and the first upper electrode **301**U, to which voltages of the opposite polarities are respectively applied, may become relatively strong. Accordingly, the first vibration plate **351** may be drawn toward the first upper electrode **301**U.

Accordingly, as the first vibration plate **351** changes its position toward the first upper electrode **301**U or the first lower electrode **301**L according to the sound signal, the first vibration plate **351** may vibrate. Accordingly, sound waves may occur from the first vibration plate **351**, and thus the sound waves may be released outwardly through the first speaker grill **201**.

FIG. **6** is a detailed configuration view illustrating the second driver **402** of FIG. **4**. In particular, FIG. **6** illustrates connection relationship between the first sound transceiver **101** and the second driver **402** when the first sound transceiver **101** functions as a mike.

The second driver **402** may include, as illustrated in FIG. **6**, a voltage adjuster **602**, a voltage multiplier **601**, and a detector **603**.

The voltage adjuster **602** may generate first and second reference voltages based on an externally applied power voltage. The first reference voltage may be a positive voltage and the second reference voltage may be a negative voltage. Herein, the second reference voltage may be ground. Meanwhile, the voltage adjuster **602** may include a band gap reference circuit and may be a high-precision regulator having tolerance to temperature variation.

The voltage multiplier **601** may generate a second bias voltage, which is a DC voltage, based on the first and second reference voltages applied from the voltage adjuster **602**. The second bias voltage applied from the voltage multiplier **601** may be applied to the first lower electrode **301**L.

The detector **603** may detect sound signals from the first sound transceiver **101**. Further, the detector **603** may further perform processes of reducing impedance of the detected sound signal, amplifying the modulated sound signal, and converting the amplified sound signal into a digital signal. A detection terminal of the detector **603** may be electrically connected to the first vibration plate **351**. Meanwhile, the detector **603** may receive the first and second reference voltages from the voltage adjuster **602**.

With the above configurations, operation of the second driver **402** and operation of the first sound transceiver **102** based on the operation of the second driver **402** are described below in detail.

When the first vibration plate **351** vibrates by sound externally applied through the first speaker grill **201**, the distance between the first vibration plate **351** and the first lower electrode **301**L may be changed. With the change of the distance, capacitance between the first vibration plate **351** and the first lower electrode **351**L may vary. The detector **603** may detect the change of the capacitance. The detected difference of the capacitance is a sound signal. The detected sound signal may have significantly high impedance, and may have low tolerance to external noise. Accordingly, the detector **603** may reduce impedance of the sound signal and amplify the signal. Then, the detector **603** may convert the amplified sound signal into a digital signal.

Meanwhile, when the first sound transceiver **101** is connected to the first driver **401** as illustrated in FIG. **5**, the second sound transceiver **102** may be connected to the second driver **402**. That is, the second sound transceiver **102** may function as a mike. Herein, although not illustrated, connection relationship between the second sound transceiver **102** and the components of the second driver **402** when the second sound transceiver **102** functions as a mike is substantially identical to connection relationship between the first sound transceiver **101** and the components of the second driver **402** when the first sound transceiver **101** functions as a mike, and thus FIG. **6** and related description may be referred to.

Further, when the first sound transceiver **101** is connected to the second driver **402** as illustrated in FIG. **6**, the second sound transceiver **102** may be connected to the first driver **401**. That is, the second sound transceiver **102** may function as a speaker. Herein, although not illustrated, connection relationship between the second sound transceiver **102** and the components of the first driver **401** when the second sound transceiver **102** functions as a speaker is substantially identical to connection relationship between the first sound transceiver **101** and the components of the first driver **401** when the first sound transceiver **101** functions as a speaker, and thus FIG. **5** and related description may be referred to.

From the foregoing, it will be appreciated that various embodiments in accordance with the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope and spirit of the present teachings. Accordingly, the various embodiments disclosed herein are not intended to be limiting of the true scope and spirit of the present teachings. Various features of the above described and other embodiments can be mixed and matched in any manner, to produce further embodiments consistent with the invention.

What is claimed is:

1. A mobile communication device comprising:

a first sound transceiver comprising a first lower electrode, a first upper electrode, and a first vibration plate between the first lower electrode and the first upper electrode;

a second sound transceiver comprising a second lower electrode, a second upper electrode, and a second vibration plate between the second lower electrode and the second upper electrode;

a position sensor configured to perform a detection of a relative positional relationship between the first and second sound transceivers; and

a controller configured to apply a sound signal to one of the first and second sound transceivers and detect a sound signal from the other one thereof, based on the detection result provided from the position sensor,

wherein the first and second lower electrodes have a groove and a hole formed within the groove and extending through corresponding lower electrodes.

2. The mobile communication device of claim **1**, wherein the controller applies a sound signal to the first sound transceiver and detects a sound signal from the second sound transceiver, when the first sound transceiver is placed higher than the second sound transceiver.

3. The mobile communication device of claim **2**, wherein the controller applies a sound signal to the first lower electrode and the first upper electrode and applies a first bias voltage to the first vibration plate, and applies a second bias voltage to the second lower electrode and detects a sound signal from the second vibration plate.

4. The mobile communication device of claim **1**, wherein the controller applies a sound signal to the second sound transceiver and detects a sound signal from the first sound transceiver, when the second sound transceiver is placed higher than the first sound transceiver.

5. The mobile communication device of claim **4**, wherein the controller applies a sound signal to the second lower electrode and the second upper electrode and applies a second bias voltage to the second vibration plate, and applies a first bias voltage to the first lower electrode and detects a sound signal from the first vibration plate.

6. The mobile communication device of claim **1**, further comprising a spacer disposed at least one of between the first lower electrode and the first vibration plate, between the first vibration plate and the first upper electrode, between the second lower electrode and the second vibration plate, and between the second vibration plate and the second upper electrode.

7. The mobile communication device of claim 1, wherein the controller comprises:

a first driver configured to amplify an externally applied sound signal and generate a first bias voltage;

a second driver configured to detect a sound signal from one of the first and second sound transceivers and generate a second bias voltage; and

a switch configured to apply the amplified sound signal and the first bias voltage applied from the first driver to one of the first and second sound transceivers and to apply the second bias voltage applied from the second driver to the other one thereof, based on the detection result provided from the position sensor.

8. The mobile communication device of claim 7, wherein, when the first sound transceiver is placed higher than the second sound transceiver,

the first driver applies a sound signal to the first lower electrode and the first upper electrode and applies a first bias voltage to the first vibration plate; and

the second driver applies a second bias voltage to the second lower electrode and detects a sound signal from the second vibration plate.

9. The mobile communication device of claim 7, wherein, when the second sound transceiver is placed higher than the first sound transceiver,

the first driver applies a sound signal to the second lower electrode and the second upper electrode and applies a first bias voltage to the second vibration plate; and

the second driver applies a second bias voltage to the first lower electrode and detects a sound signal from the first vibration plate.

10. The mobile communication device of claim 7, wherein the first driver comprises:

an amplifier configured to amplify an externally applied sound signal;

a transformer configured to transform the amplified sound signal applied from the amplifier; and

a bias power configured to generate the first bias voltage.

11. The mobile communication device of claim 7, wherein the second driver comprises:

a voltage adjuster configured to generate first and second reference voltages based on an externally applied power voltage;

a voltage multiplier configured to generate a second bias voltage based on the first and second reference voltages applied from the voltage adjuster; and

a detector configured to detect a sound signal from one of the first and second sound transceivers.

12. The mobile communication device of claim 11, wherein the detector further reduces impedance of the detected sound signal, amplifies the modulated sound signal, and converts the amplified sound signal to a digital signal.

13. The mobile communication device of claim 1, wherein the position sensor is a gravity sensor.

14. A mobile communication device comprising:

a first sound transceiver comprising a first lower electrode, a first upper electrode, and a first vibration plate between the first lower electrode and the first upper electrode,

wherein the first upper electrode includes a plurality of holes defined therein, the holes arranged in a mesh shape, and

wherein the first lower electrode comprises at least one groove, the groove being circular in shape and formed above a center portion of the first lower electrode;

a second sound transceiver comprising a second lower electrode, a second upper electrode, and a second vibration plate between the second lower electrode and the second upper electrode,

wherein the second upper electrode includes a plurality of holes defined therein, the holes arranged in a mesh shape, and

wherein the first lower electrode comprises at least one groove, the groove being circular in shape and formed above a center portion of the first lower electrode;

a position sensor configured to perform a detection of a relative positional relationship between the first and second sound transceivers;

a controller configured to apply a sound signal to one of the first and second sound transceivers and detect a sound signal from the other one thereof, based on the detection result provided from the position sensor;

a first spacer disposed at least one of between the first lower electrode and the first vibration plate or between the second lower electrode and the second vibration plate; and

a second spacer disposed at least one of between the first vibration plate and the first upper electrode or between the second vibration plate and the second upper electrode.

15. The mobile communication device of claim 14, wherein the controller applies a sound signal to the first sound transceiver and detects a sound signal from the second sound transceiver, when the first sound transceiver is placed higher than the second sound transceiver.

16. The mobile communication device of claim 15, wherein the controller applies a sound signal to the first lower electrode and the first upper electrode and applies a first bias voltage to the first vibration plate, and applies a second bias voltage to the second lower electrode and detects a sound signal from the second vibration plate.

17. The mobile communication device of 14, wherein the controller applies a sound signal to the second sound transceiver and detects a sound signal from the first sound transceiver, when the second sound transceiver is placed higher than the first sound transceiver.

18. The mobile communication device of claim 17, wherein the controller applies a sound signal to the second lower electrode and the second upper electrode and applies a second bias voltage to the second vibration plate, and applies a first bias voltage to the first lower electrode and detects a sound signal from the first vibration plate.

19. The mobile communication device of claim 14, wherein the first and second lower electrodes have a hole formed within the groove and extending through corresponding lower electrodes.

20. The mobile communication device of claim 14, wherein the controller comprises:

a first driver configured to amplify an externally applied sound signal and generate a first bias voltage;

a second driver configured to detect a sound signal from one of the first and second sound transceivers and generate a second bias voltage; and

a switch configured to apply the amplified sound signal and the first bias voltage applied from the first driver to one of the first and second sound transceivers and to apply the second bias voltage applied from the second driver to the other one thereof, based on the detection result provided from the position sensor.

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